Performance improvement evaluation of forward aeromedical evacuation platforms in Operation Enduring Freedom

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BACKGROUND: The following three helicopter-based medical evacuation platforms operate in Southern Afghanistan: the US Army emergency medical technician (basic)–led DUSTOFF, US Air Force paramedic-led PEDRO, and UK physician-led medical emergency response team (MERT). Nearly 90% of battlefield deaths occur in the prehospital phase, comparative outcomes for these en route care platforms are unknown. The objective of this investigation was to characterize the nature of injuries in patients transported by three evacuation platforms. In addition, it aimed to compare observed versus predicted mortality among these provider groups.

METHODS: A performance improvement study involving 975 coalition patients injured in Southern Afghanistan, transported from the point of injury to a military hospital, was performed. All patients were alive on admission with prehospital documentation recorded in the US Department of Defense Trauma Registry from June 2009 to June 2011. The main outcome measure was in-hospital mortality and observed versus predicted (Trauma and Injury Severity Score [TRISS]) survival were the primary end points.

RESULTS: MERT transported more amputation and polytrauma casualties and included patients with higher mean Injury Severity Score (ISS) compared with PEDRO and DUSTOFF (16 [13] vs. 11 [10] and 10 [10] respectively; $p < 0.001$). DUSTOFF was excluded from the subgroup analysis owing to insufficient numbers of severely injured casualties with only one death. The overall mortality for MERT and PEDRO was similar (4.2% vs. 4.6%, $p = 0.967$). Stratifying by ISS, there was lower mortality in MERT compared with PEDRO in the range of 20 to 29 (4.8% vs. 16.2%, $p = 0.021$). The observed mortality among PEDRO casualties was as predicted with the exception of the range of 20 to 29, while mortality in MERT was lower than predicted for all ISS groups with greater than 10.

CONCLUSION: MERT achieves greater than predicted survival, which may be related to the additional capabilities onboard. This supports the adoption of a versatile medical evacuation system with scalable crew and equipment configurations that adapt to meet the medical, tactical, and operational needs of future conflicts. (*J Trauma Acute Care Surg*. 2013;75: S157–S163. Copyright © 2013 by Lippincott Williams & Wilkins)

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KEY WORDS: Medical evacuation (MEDEVAC); en route care; combat trauma.

A recent US Department of Defense (DoD) Joint Trauma System (JTS) study defining causes of death during 10 years of war showed that nearly 9 of 10 battlefield deaths occurred before reaching a military hospital with a surgical capability and that as many as 25% percent of these injuries were potentially survivable.[1] Despite advances in surgical care and resuscitation during this period, the greatest burden of battlefield mortality remains in the prehospital environment, highlighting the critical importance of care at the point of injury (POI) and en route to a hospital.

Battlefield POI care is termed *tactical combat casualty care* and focuses on the early application of lifesaving measures by the casualty, their buddies, and combat medics.[2] Adherence to this practice has demonstrated a reduction in preventable battlefield mortality;[2] however, little has been published examining en route care. Direct analysis of en route care for recent conflicts has been a challenge, in part owing to lack of relevant data in the DoD Trauma Registry (DoDTR) until 2009 and difficulties in piecing together disparate operational data sources pertaining to patient evacuation.

Three helicopter-based medical evacuation (MEDEVAC) platforms have been used during Operation Enduring Freedom (OEF), each with unique doctrinal considerations including onboard medical capability. Historically, the US Army's DUSTOFF platform has conducted POI casualty evacuation missions. DUSTOFF providers are typically medics or emergency medical technician (EMT)–trained at the basic level.[3] The US Air Force Expeditionary Rescue Squadron, known as PEDRO, was designed for search and rescue missions. However, in Afghanistan, the PEDRO's role was expanded to include POI transport in select scenarios. PEDRO flights are manned by EMTs credentialed at the paramedic/advanced (highest) level. The United Kingdom fields a platform referred to as the medical emergency response team (MERT). The MERT platform is scalable, meaning the providers can include a combination of skill sets based on unique mission requirements.[4] The basic crew configuration includes a

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critical care nurse (RN) and paramedic; however, this team can be enhanced by the addition of a second paramedic and a senior emergency medicine physician. This "enhanced" configuration is the current standard in Afghanistan.

The objective of this study was to characterize the nature of traumatic injuries sustained by combat casualties transported by the three MEDEVAC platforms currently used in Southern Afghanistan. An additional objective was to compare in-hospital mortality outcomes as well as predicted and observed mortality among casualties transported by these platforms.

PATIENTS AND METHODS

The US Central Command Joint Combat Casualty Research Team (JC2RT) and the deployed US Central Command Joint Theater Trauma Medical Director approved the study as a retrospective performance improvement project. The full study was further supported by the JTS, a directorate in the US Army Institute of Surgical Research (USAISR) at Fort Sam Houston (San Antonio), Texas.

Study Cohort

The study cohort consisted of North Atlantic Treaty Organization (NATO) and non-NATO military casualties transported from POI to a Role 3 military hospital at either Camp Bastion or Kandahar Air Field during a 24-month period (June 2009 to June 2011). These hospitals, which are equivalent to a civilian Level II or III trauma center in the United States, are capable of providing sophisticated surgical and critical care including neurosurgical care in some cases. For inclusion, casualties had to have been transported by one of the three study MEDEVAC platforms and must have been alive on admission and had documented prehospital vital signs.

MERT's clinical crew consisted of one physician, one nurse, and two paramedics. This configuration enables delivery of advanced interventions (Table 1) such as prehospital blood administration and rapid sequence intubation. The MERT generally uses a CH-47 Chinook, which accommodates up to eight litter patients—more than any other platform used for MEDEVAC in Afghanistan.

PEDRO's clinical crew (Table 1) is composed of a two-man paramedic team that flies onboard the smaller HH-60 Pavehawk helicopter. PEDRO's paramedics are termed *pararescuemen* or "PJ" and undergo additional military training to provide care in active combat environments. In addition, since late 2010, PJs have been equipped to administer prehospital blood.

DUSTOFF is staffed by two EMT-B level flight medics and uses the UH-60A Blackhawk helicopter, which, although very similar to the Pavehawk, is distinguished by the characteristic Red Cross and is not armed with offensive weapons, unlike the other two study platforms. Moreover, unlike the other platforms, DUSTOFF did not possess the ability to administer blood products in-flight during the study period.

Data Sources and Covariates

The data set was composed of prehospital clinical data amalgamated from three prospectively captured data sources as follows: (1) DoDTR (2) Patient Evacuation Coordination Center (PECC) logs, and (3) casualty care records/prehospital report forms. The DoDTR was established as the Joint Theater Trauma Registry in 2004 as a process improvement tool, collecting information on injured casualties admitted to Role 3 hospitals.[5] Data collection was abstracted from records and included demographics, admission physiology, injury pattern, mechanism and severity, as well as mortality. Once data elements were compiled, casualties were grouped into one of the three study MEDEVAC platforms. The PECC in Afghanistan is responsible for determining which MEDEVAC platform to dispatch for casualty retrieval.[6,7] PECC dispatchers use a combination of tactical (e.g., distance, terrain, enemy action, asset availability) and

TABLE 1. Characteristics of MEDEVAC Platforms

	MERT CH-47 Chinook	PEDRO HH-60 Pave Hawk	DUSTOFF UH-60 Blackhawk
Airframe speed			
Max	170 knots	150 knots	150 knots
Cruise	130 knots	130 knots	130 knots
Notice to movement	20 min	15 min	Varies based on availability of escort
Crew composition	Emergency nurse (1)	EMT-paramedic (2)	EMT-basic (1)
	Paramedic (2)	>1,500 h of coursework and clinical experience	>160 h of coursework and clinical experience
	Senior emergency physician (1)		
	soldiers (4)		
Patient capacity	8* to 9 litter	2 to 3 litter	3 to 6** litter
Medical capabilities	Consultant lead	Trauma ambulance	Extensive immediate care
	Advanced resuscitation	Advanced resuscitation	Onboard oxygen generation
	Advance airway management	Advanced airway management: rapid sequence induction of anesthesia to protect a compromised airway	Basic Airway management: able to intubate moribund patients without anesthetic agents, as part of advanced life support protocols
	Tranexamic acid administration		
Forward damage-control resuscitation ability	Catastrophic bleeding packed red blood cell and fresh frozen plasma (4:4) Thoracic trauma management circulatory support	Since October 2010, packed red blood cell and fresh frozen plasma (2:2)	Since October 2011, packed red blood cell and fresh frozen plasma (1:1)

*As configured in OEF.
**Three-litter configuration in OEF; maximum of 6 with carousel.

medical (e.g., mechanism of injury, injury details, and casualty physiology) information in an effort to determine which evacuation asset is best suited for each mission.

Outcomes

The primary end point was in-hospital mortality. Casualties who died in the field or were declared dead in the prehospital phase of care (field or en route) were categorized as killed in action and were excluded from the study. Injury patterns were reported using Abbreviated Injury Scale (AIS) scores per body region.[8] Traumatic injuries were classified into two groups: (1) isolated trauma and (2) polytrauma. Isolated trauma refers to casualties with injuries to only one body region. These casualties were then further subdivided into minor (defined by an AIS score < 3) injuries and severe (defined by an AIS score ≥ 3) injuries. Polytrauma includes casualties with injuries present in two or more body regions. To reflect the variation in injury burden, subgroups were generated using the AIS score by body region: (1) minor/minor polytrauma, which includes casualties with minor injuries (AIS score < 3) in more than two body regions; (2) severe/minor polytrauma, which consists of casualties with a predominant severe injury (AIS score ≥ 3) to one body region and minor injuries (AIS score < 3) to subsequent body regions; and (3) severe/severe polytrauma, which consists of casualties with severe wounds (AIS score ≥ 3) to two or more body regions.

The 2005 civilian Injury Severity Score (ISS) was used to summarize individual casualty injury patterns and was grouped into four categorical bins:[9] minor wounds with ISS of less than 10, moderate wounds with ISS of 10 to 19, severe wounds with ISS of 20 to 29, and critical/catastrophic wounds with ISS of 30 to 75. In addition, the proportions of casualties sustaining single or multiple traumatic amputation(s) were compared. Only casualties with traumatic amputations of whole or partial major limbs were included in this subgroup.[10]

Statistical Analysis

Initially, crude mortality was compared across the three platforms and then per a priori ISS groupings. Further analysis was performed using Trauma and Injury Severity Score (TRISS) methodology. TRISS is a combined severity index, which calculates a probability of survival for each casualty based on a logistic regression model that incorporate anatomic (ISS) and physiologic (Revised Trauma Score [RTS]) severity measures along with age and injury type (blunt vs. penetrating). This combined index identifies patients with unexpected outcomes for comparison across groupings while controlling for difference in injury severity patterns.[11] The RTS is a physiologic scoring system calculated as the sum of the weighted products of three key vital signs as follows: systolic blood pressure, Glasgow Coma Scale (GCS) score, and respiratory rate.[12] For this study, the first set of vital signs recorded in the prehospital documentation was used to calculate the RTS for TRISS analysis. In accordance with TRISS methodology, definitive patient outcomes were evaluated using Z and W statistics, which compare two patient groups as follows: actual survivors and expected survivors. The Z statistic determines if the observed mortality for each ISS grouping was statistically significant ($p < 0.05$) from the predicted death rate.[13] If Z exceeds or equals 1.96, there are statistically, significantly more survivors than expected. Similarly, if Z is less than or equal to −1.96, there are statistically, significantly fewer survivors. Once significance is established, W scores are calculated to quantify the clinical significance, the average increase/decrease in the number of survivors/nonsurvivors per 100 patients treated compared with the norm. As TRISS methodology depends on distribution and volume of mortality, any group with a low mortality is typically excluded from the analysis.

Categorical data were summarized using crude rates and percentages. Mortality outcomes were compared using χ^2 tests. Continuous variables were tested for normality and those that met the criteria for normality were summarized using means and SDs. Platform comparisons were analyzed using Student's t test and analysis of variance. Nonnormally distributed continuous variables were analyzed using the Wilcoxon test, and medians with interquartile ranges were used to provide summary statistics. Statistical significance was set at $p < 0.05$. All data analyses for this study were performed using SAS 9.2 (Cary, NC).

RESULTS

The initial query revealed 1,305 records for review. Casualties were excluded for the following reasons: duplicate entry (n = 244), killed in action (n = 60), interfacility transfer (n = 8), and unknown MEDEVAC platform (n = 18). The final study cohort consisted of 975 casualties stratified by platform: MERT (n = 543), PEDRO (n = 326), and DUSTOFF (n = 106).

There was no difference in the mean age of casualties across the MEDEVAC platforms ($p = 0.328$); however, there was a difference in distribution of casualty categories (US, NATO, and non-NATO military) ($p < 0.001$) (Table 2). Specifically, more US casualties were transported by DUSTOFF, while MERT predominantly transported NATO military casualties. PEDRO transported equal numbers of US and NATO military casualties, while non-NATO military were transported equally on the three platforms. Analysis of injury mechanism demonstrated that MERT was used to transport a greater proportion of casualties injured from explosive mechanisms, compared with the other platforms ($p < 0.001$). PEDRO transported the greatest proportion of gunshot wounds. In terms of prehospital physiology, the MERT cohort was more hypotensive ($p < 0.001$) and tachycardic ($p < 0.001$) but not more tachypneic ($p = 0.001$) than the DUSTOFF and PEDRO groups (Table 2).

The mean ISS of casualties transported via MERT was greater than PEDRO or DUSTOFF (16 [13] vs. 11 [10] and 10 [10], respectively; $p < 0.001$) (Table 3). A larger portion of casualties transported by PEDRO and DUSTOFF sustained isolated-minor trauma when compared with MERT (26.4% and 29.2% vs. 15.8%, respectively; $p < 0.001$) (Table 3). Similar rates of isolated severe trauma were observed across the three MEDEVAC platforms ($p = 0.301$). When considering polytrauma patterns, DUSTOFF and PEDRO transported similar proportions of minor polytrauma, which was greater than MERT (31.1% and 24.5% vs. 18.8%, respectively; $p = 0.008$). Correspondingly, MERT carried greater proportions of patients with severe polytrauma patterns (Table 3). MERT also transported the highest number of patients with at least one amputation when compared with PEDRO and DUSTOFF (23.4% vs. 5.8%

TABLE 2. Demographic Characteristics and Prehospital Physiology per MEDEVAC Platform

	MERT	PEDRO	DUSTOFF	p
n	543	326	106	
Age, mean (SD)	24.1 (4.8)	23.6 (4.1)	24.4 (5.8)	0.328
Casualty category, n (%)				
US military	151 (27.8)	127 (39.0)	78 (73.6)	<0.001*
NATO military	240 (44.2)	111 (34.0)	7 (6.6)	
Non-NATO military	152 (28.0)	88 (27.0)	21 (19.8)	
Mechanism of injury, n (%)				
Gunshot wound/ballistics	133 (24.5)	10 (32.8)	24 (22.6)	<0.001*
Blast	391 (72.0)	177 (54.3)	67 (63.2)	
Other	19 (3.5)	42 (12.9)	15 (14.2)	
Prehospital vitals, mean (SD)				
Systolic blood pressure	106 (31)	121 (27)	124 (26)	<0.001*
Heart rate	104 (31)	92 (23)	97 (23)	<0.001*
Unassisted respiratory rate	22 (16)	19 (6)	19 (7)	0.001*

*p value significance based on 0.05.
blast, all explosive devices/blast; other, all other mechanisms of injury.

and 8.5%, respectively; $p < 0.001$) (Table 3). In addition, of the 103 patients sustaining multiple amputations, 85% were flown by MERT, significantly greater than any the other MEDEVAC group ($p < 0.001$).

The overall mortality in the MERT and PEDRO groups was similar (4.2% vs. 4.6%, $p = 0.967$) (Table 4). Mortality in the DUSTOFF group was 0.9% (one casualty), and because 95% of casualties in this group had an ISS of less than 20, DUSTOFF was excluded from further mortality subgroup analyses. When mortality was compared between MERT and PEDRO in each of four ISS bins, there was no difference in the lower (<10 and 10–19) and highest (30–75) ISS categories (Table 4). However, mortality in casualties with an ISS of 20 to 29 was lower in the MERT compared with the PEDRO group (4.8% vs. 16.2%, $p = 0.021$).

Following stratification by injury severity, TRISS methodology was used to compare the number of observed versus the predicted survivors within MERT and PEDRO (Table 5). Casualties in the MERT group achieved predicted mortality for the lowest ISS grouping (< 10) (Fig. 1*A*). However, the observed mortality rates were statistically lower than predicted in the three highest severity bins as evidenced by positive Z scores greater than 1.96 in the MERT cohort (Table 5). PEDRO achieved the expected mortality rate in all ISS groupings except the 20 to 29 bin where the observed rate was found to be statistically higher than predicted (16.2% vs. 8.1%; $Z = -2.736$) (Fig. 1*B*).

DISCUSSION

This study characterizes MEDEVAC capabilities transporting combat casualties in Southern Afghanistan during OEF. The MERT platform transported a cohort of patients sustaining a greater injury burden than those transported by the PEDRO or DUSTOFF assets. The MERT platform achieved a lower than

TABLE 3. Injury Pattern by MEDEVAC Platform

	MERT	PEDRO	DUSTOFF	p
n	543	326	106	
ISS, mean (SD)	16 (13)	11 (10)	10 (10)	<0.001*
Crude mortality, n (%)	23 (4.2)	15 (4.6)	1 (0.9)	—
Injury burden, n (%)				
Isolated minor	86 (15.8)	86 (26.4)	31 (29.2)	<0.001*
Isolated severe	54 (9.9)	35 (10.7)	6 (5.7)	0.301
Polytrauma minor-minor, n (%)	102 (18.8)	80 (24.5)	33 (31.1)	0.008*
Polytrauma severe-minor, n (%)	196 (36.1)	87 (26.7)	27 (25.5)	0.005*
Polytrauma severe-severe, n (%)	105 (19.3)	38 (11.7)	9 (8.5)	0.001*
Severe trauma, n (%)	355 (65.4)	160 (49.1)	42 (39.6)	<0.001*
Major amputations, n (%)	127 (23.4)	19 (5.8)	9 (8.5)	<0.001*
Single	39 (7.2)	11 (3.4)	2 (1.8)	0.049*
Double	74 (13.6)	7 (2.1)	6 (5.6)	0.173
Three or more	14 (2.6)	1 (0.3)	1 (0.9)	0.741

*p value significance based on 0.05.

TABLE 4. Mortality Analysis by MEDEVAC Platform

ISS Group	MERT		PEDRO		p
	All Casualties	Deaths, n (%)	All Casualties	Deaths, n (%)	
Mild, <10	207	4 (1.9)	182	2 (1.1)	0.689
Moderate, 10–19	154	3 (1.9)	96	4 (4.2)	0.434
Severe, 20–29	124	6 (4.8)	37	6 (16.2)	0.021*
Critical, 30–75	58	10 (17.2)	11	3 (27.3)	0.435
Total	543	23 (4.2)	326	15 (4.6)	0.967

*p value significance based on 0.05.

predicted mortality rate among casualties with moderate, severe, and critical/catastrophic wounding. Patients transported by PEDRO who sustained minor, moderate, or critical/catastrophic wounding had a mortality rate as expected; however, a greater than expected mortality rate was observed in the severely wounded category.

One of the first studies to assess the clinical capability of en route care during the war in Afghanistan was by Mabry et al.[3] This study examined 671 casualties with an ISS of greater than 15 transported by DUSTOFF and analyzed mortality among casualties treated by Critical Care Flight Paramedics compared with EMT-basic flight medics (standard MEDEVAC). The unadjusted mortality was higher in casualties treated by the standard EMT-basic (15% vs. 8%) and after adjustment for confounding variables in a logistic regression, the odds ratio of death in the Critical Care Flight Paramedics group was 0.34. Findings of the current study confirm and extend the report of Mabry et al. highlighting for the first time the paramedic capabilities on the PEDRO platform as well as the effectiveness of the advanced clinical capability associated with the MERT.

In a more recent report, Morrison et al.[14] used the UK trauma registry to examine consecutive patients admitted to a NATO hospital in Southern Afghanistan evacuated by the same platforms as the current study during a slightly longer period. Specifically, Morrison et al. compared mortality among casualties evacuated via MERT-E (n = 1,093) with that among casualties (n = 628) evacuated via non–MERT-E (PEDRO and DUSTOFF, collectively). The Morrison analysis stratified casualties into ISS categories (1–15, 16–50, and 51–75) and reported lower mortality among casualties in the middle ISS category who were transported by MERT-E (12% vs. 18%). The current study corroborates the findings from the study of Morrison et al., which uses a different data set and methods, and similarly suggests a survival benefit in a select group of combat casualties with severe but survivable injuries when transported by the advanced en route care capability on board MERT.

In aggregate, this emerging body of evidence is important within the context of a recent study of preventable battlefield deaths by the US JTS, which analyzed 4,596 US military deaths in Iraq and Afghanistan and demonstrated that 87% of those killed in combat died in the prehospital setting.[1] Improvements in prehospital care will yield the greatest gains in survivability, a point which will become increasingly important in future conflicts where missions may be longer in duration.

The current study has important implications for civilian transport systems, specifically; the en route use of advanced clinical interventions may improve outcomes in trauma patients. This complements evidence from Europe, where physician staffed helicopter emergency medical services are more common than in the United States and are associated with a survival benefit.[9] However, the findings from the current study cannot be directly extrapolated to the civilian setting because the outcomes from the MERT group may be contingent on capability (i.e., airframe size, number of personnel, etc.) rather than the presence of a physician alone.

Battle-related prehospital deaths are classified as killed in action with no distinction between deaths that occur in the field or en route. This convention, combined with the retrospective nature of this study, and the fact that PEDRO and DUSTOFF medical crew cannot declare an en route death make it impossible to ascertain the en route casualty mortality rates between platforms. As a result, this evaluation excluded 60 casualties

TABLE 5. TRISS Observed Versus Predicted Outcome Statistics

ISS Group	MERT					PEDRO				
	Actual Survivors	Predicted Survivors	*Z* Statistic	Stat Sig	*W* Score	Actual Survivors	Predicted Survivors	*Z* Statistic	Stat Sig	*W* Score
<10	203	202	0.635	NS	0	180	180	0.000	NS	0
10–19	151	147	2.001	Significantly more survivors	3	92	93	0.000	NS	−1
20–29	118	99	5.714	Significantly more survivors	15	30	34	−2.736	Significantly fewer survivors	−11
30–75	48	32	5.755	Significantly more survivors	28	9	7	0.908	NS	0
Totals	520	480	—	—	—	311	314	—	—	—

Z statistic, test for the statistical significance at $p < 0.05$ level
W score, the number of survivor more (less) than would be expected from the outcome norms per 100 patients treated.
NS, not significant; Stat Sig, significance interpretation.

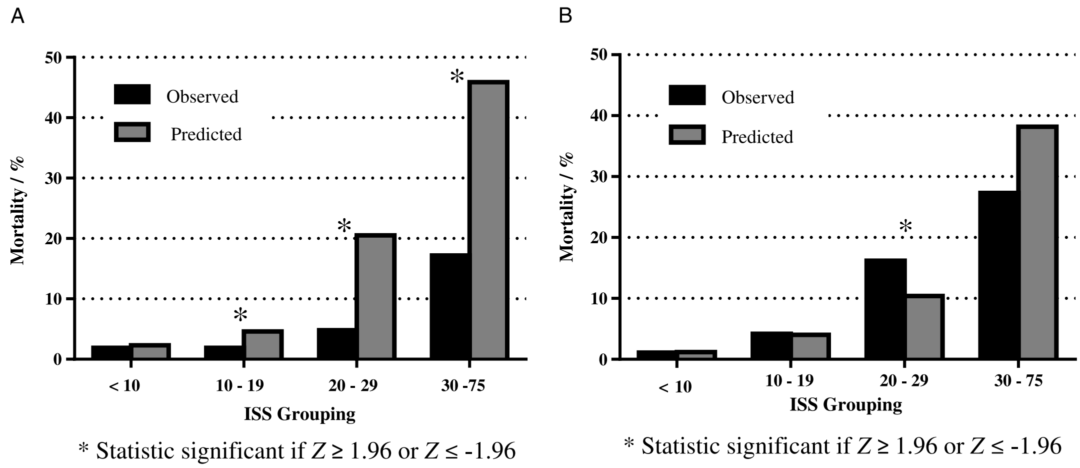

Figure 1. *A*, The observed versus the predicted mortality for the MERT platform per ISS groupings. *B*, The observed versus the predicted mortality for the PEDRO platform per ISS groupings.

identified as killed in action, which represents two thirds of the platform deaths during the period of study. The data of Eastridge et al.[1] suggest that at least 75% of the casualties killed in action sustained a nonsurvivable injury, indicating that these deaths would have occurred indiscriminate of platform type. Inclusion of prehospital deaths would have therefore introduced a bias against MERT because MERT is preferentially tasked with evacuating the most severely injured casualties (Table 3). Yet, our inability to account for those casualties that had potentially survivable injuries (up to 25% as suggested by Eastridge et al.[1]) but died en route indubitably limits our ability to assess the quality of care provided onboard each platform. Moreover, platform response times and additional factors that may have influenced survival opportunity such as terrain, enemy action, and adverse weather conditions are also unaccounted for in this investigation. However, several recent studies have shown no significant difference in the overall mission times for MERT and PEDRO.[14,15] The complex combat environments under which PEDRO was likely often used may have introduced a bias into the study results, and this dynamic must be considered in final characterization of PEDRO outcomes in this evaluation.

In addition, the overall low number of fatalities (n = 39) resulted in the exclusion of DUSTOFF from the TRISS subgroup analysis. The study would greatly benefit from a larger sample size providing the power to allow a comparison across all platforms. Similarly, TRISS methodology has a number of shortcomings; most notably, current coefficients are based on civilian trauma data and have yet to be validated using combat trauma patients.[16,17] Moreover, TRISS is extremely sensitive to missing data; this can prove problematic, particularly in the context of prehospital documentation. Furthermore, there are inherent limitations associated with retrospective registry studies, in particular, limited or missing data. As such, data on prehospital blood and tranexamic acid use or other lifesaving interventions including airway procedures are not taken into consideration and may have affected the outcomes on each of the platforms. Detailed information on prehospital adjuncts/interventions requires in-depth chart review and is an area to explore for future research on this topic. Finally, the study is unable to address the independent impact of provider training/skill set on patient outcomes. Despite these limitations, this study provides a benchmark in the characterization of en route care capabilities on a modern battlefield and forms the basis for future studies and operational planning.

CONCLUSION

Advanced provider en route care platforms, including paramedic- and physician-led capabilities, are used effectively to evacuate the most severely injured casualties on the battlefield. Despite unique operational and tactical considerations, the paramedic-led PEDRO platform accomplishes the predicted survival for patients sustaining mild, moderate, and critical/catastrophic wounding. The physician-led MERT capability transports a higher percentage of severely injured casualties including those with polytrauma and multiple amputations while achieving greater than predicted survival. Further research on the mechanism(s) underlying the apparent survival benefit associated with MERT and enhancement of existing platform capability and configuration is warranted to develop optimal medical evacuation doctrine for future conflicts.

AUTHORSHIP

A.A. and C.M.O. take responsibility for the integrity of the data and the accuracy of the data analysis. A.A., C.M.O., and E.K. contributed in the study concept and design. A.A. and C.M.O. performed the acquisition of data. A.A., C.M.O., J.B., F.B., B.J.E., and E.K. performed the analysis and interpretation of data. A.A., C.M.O., J.B., F.B., B.J.E., and E.K. drafted the manuscript. A.A., C.M.O., J.B., and E.K. provided critical revision of the manuscript for important intellectual content. A.A. and C.M.O performed the statistical analysis. J.B. provided administrative, technical, or material support. E.K. provided study supervision.

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DISCLOSURE

All authors have completed and submitted the ICMJE form for disclosure of potential conflicts of interest. There were no conflicts reported.
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